UNITED STATES DEPARTMENT OF THE INTERIOR

INVESTIGATIONS OF METHODS AND EQUIPMENT USED IN STREAM GAGING

PART 2. INTAKES FOR GAGE WELLS

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Part 2. INTAKES FOR GAGE WELLS

BY

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Prepared in collaboration with the
HYDRAULIC LABORATORY COMMITTEE
OF THE GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATIONS

TABLES

INVESTIGATIONS OF METHODS AND EQUIPMENT USED IN STREAM GAGING

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By C. H. Pierce

ABSTRACT

Various devices attached to the ends of intake pipes to gage wells have been used by engineers of the Geological Survey in attempts to eliminate the "draw-down," or difference in the heights of water in the well and in the river at stations for the measurement of stream flow. About 90 different devices and arrangements of intakes were tested at the National Hydraulic Laboratory in order to obtain definite information regarding the performance of the various devices and their effectiveness in eliminating draw-down.

Preliminary tests were made of ⅛-scale models, an intake pipe 3 inches in diameter being taken as the basic size, with water flowing at 2.8 feet per second at the intake. Models that gave good results in the prelininary tests were selected for additional tests at full size. The models were tested for different positions corresponding to angularity of flow of the water passing the intake as well as for the normal position of intake perpendicular to the vertical plane in the direction of flow. The results of the tests of the ⅛-scale models and the full-size models are given in the tables.

As a result of the tests, several different devices were selected by the laboratory committee of the Geological Survey for recommendation to the district engineers of the Survey as being effective in eliminating draw-down at stations for the measurement of stream flow. Designs for use in constructing the devices are shown in the illustrations.

INTRODUCTION

The general use of water-stage recorders in obtaining records of stream flow has tended to the development of certain types of structures specially adapted to the purpose of providing shelter for the recording instruments and furnishing the necessary facilities for their operation. The instruments are installed over stilling wells, which are designed to eliminate the dynamic disturbances, such as the effects of wave action and pulsations, commonly found in natural streams, and to maintain a height of water that will be the same as the static head of the water in the stream channel or have a direct relation to it. If the stilling well is constructed in the bank of the river for protection against damage by floods or by freezing, a connection between the

water in the river and the water in the well is made by means of an intake pipe. These intake pipes may be from 2 to 4 inches in diameter and of various lengths depending upon the distance from the stilling well to the point in the river at which the height of the water surface is to be measured. Unless the stream end of the intake pipe is protected from the dynamic effects of the water flowing past it there may be a draw-down or a building up of the height of water in the well as compared with the height of water in the river channel at the end of the pipe. These differences in height have been found to be as much as 1 foot, and they vary not only for different stages but they may also vary for the same stage of the river. Stilling wells attached to bridge piers or abutments are generally provided with small openings whereby the water is admitted directly into the wells without the use of intake pipes. Under those circumstances the dynamic effects of the water may be even more pronounced than those experienced where the connection is made through intake pipes. Except in rivers where heavy silt loads make the use of intake pipes impracticable it is possible that intake connections to stilling wells on bridge piers and abutments might be made in a manner similar to that used with stilling wells in river banks.

Various devices attached to the ends of intake pipes have been used by engineers of the Geological Survey in attempts to eliminate the so-called "draw-down," or difference in the heights of the water in the well and in the river at stream-flow measurement stations, and in October 1936 a letter was sent to all the district engineers of the Survey requesting suggestions in regard to designs of intake devices to be used in a series of tests in order to obtain information as to the most satisfactory devices. A large number of suggestions were received in response to that letter, and arrangements were made with the National Bureau of Standards for the use of its laboratory facilities in making a series of comparative tests of the devices that had been suggested.

ADMINISTRATION AND PERSONNEL

The work in the laboratory and office incident to the preparation of this report was performed under the general administrative direction of N. C. Grover, chief hydraulic engineer, and C. G. Paulsen, acting chief hydraulic engineer after the retirement of Mr. Grover on January 31, 1939. Mr. Paulsen also administered the work as chief of the division of surface water.

The methods and procedures used in conducting the investigation were arranged by the hydraulic laboratory committee of the water-resources branch of the Geological Survey, consisting of Lasley Lee, C. H. Pierce, and O. W. Hartwell. H. C. Beckman and C. V. Youngquist became members of the committee after the death of Mr. Lee

in November 1937. Laboratory tests of the ⅛-scale models were made by Messrs. Lee, Pierce, and Hartwell, assisted by W. S. Eisenlohr, Jr., and A. D. Ash. Tests of the full-size models were made by Mr. Eisenlohr. The analyses of the data and the recommendations based on the results of the tests were made by the laboratory committee assisted by Mr. Eisenlohr.

COOPERATION AND ACKNOWLEDGMENTS

The facilities of the National Hydraulic Laboratory were provided by the National Bureau of Standards. The laboratory staff under the direction of H. N. Eaton furnished advice and assistance in the conduct of the work, particularly in regard to details of laboratory procedure.

PURPOSE AND SCOPE OF THE INVESTIGATION

The investigation was arranged for the purpose of testing the various designs of intake devices that had been suggested by engineers of the Geological Survey as being helpful in eliminating the effects of draw-down in gage wells. Some forms of intakes were tested for the purpose of obtaining standards of comparison rather than because of the merits of the particular forms. Tests of the draw-down when using a straight pipe with the outer end square-cut and open to the action of the water were made for purposes of comparison. Most of the models tested were composed of standard pipe fittings or accessories that could readily be obtained or constructed in the field. A few models of more complicated design were constructed for purposes of tests.

The tests were made with water passing the intake at velocities of 1.0, 2.0, 2.8, and 3.65 feet per second. The limitations of the water available for testing the full-size models in the large flume did not permit the use of higher velocities.

INTAKE DEVICES SELECTED FOR LABORATORY TESTS

The suggestions as to forms of intake devices received from the engineers of the Geological Survey were arranged for use in the series of tests, all the suggestions that were sufficiently specific and practicable for laboratory tests being included. Several other devices and arrangements of pipe fittings were selected by the laboratory committee, so that a total of about 90 different devices and arrangements were prepared for tests. The different devices and arrangements are listed below.[1] The dimensions given are those for use with an intake pipe 3 inches in diameter.

[1] The serial numbers used in this list have been rearranged from those originally assigned to the various devices.

TABLE 1.—*Intake devices selected for laboratory tests*

STANDARD PIPE FITTINGS ATTACHED TO END OF INTAKE PIPE

1. 90° elbow with open end pointing upstream.
2. Same as 1, except the open end pointing downstream.
3. Same as 1, except the open end pointing downward.
4. 45° elbow with open end pointing upstream.
5. Same as 4, except the open end pointing downstream.
6. Same as 4, except the open end pointing downward.
7. Tee, with run on intake pipe, the outlet pointing upstream.
8. Same as 7, except the outlet pointing downstream.
9. Same as 7, except the outlet pointing downward.
10. Same as 7, except the outer end of run plugged.
11. Same as 7, except the outer end of run plugged and the outlet pointing downstream.
12. Same as 7, except the outer end of run plugged and the outlet pointing downward.
13. Same as 7, except with a 12-inch nipple in outlet pointing upstream.
14. Same as 7, except with a 12-inch nipple in outlet pointing downstream.
15. Same as 7, except with a 12-inch nipple in outlet pointing downward.
16. Same as 7, except with a 12-inch capped nipple on the outer end of the run.
17. Same as 7, except with a 12-inch capped nipple on the outer end of the run and the outlet pointing downstream.
18. Same as 7, except with a 12-inch capped nipple on the outer end of the run and the outlet pointing downward.
19. A 4-inch to 3-inch reducing elbow with the 4-inch opening pointing downward.
20. A 3-inch to 2-inch reducing elbow with the 2-inch opening pointing downward.
21. A 4-inch to 3-inch reducing coupling with the 4-inch opening outward.
22. A 3-inch to 2-inch reducing coupling with the 2-inch opening outward.
23. A four-way cross in horizontal position.
24. Same as 23, except the downstream opening plugged.
25. Same as 23, except the upstream opening plugged.
26. Same as 23, except the streamward opening plugged.
27. Same as 23, except the downstream and streamward openings plugged.
28. Same as 23, except the upstream and streamward openings plugged.
29. Same as 23, except with a 12-inch nipple in the streamward opening.
30. Same as 23, except with a 12-inch capped nipple in the streamward opening.
31. Same as 23, except with a 12-inch open nipple in the streamward opening, the downstream outlet plugged.
32. Same as 23, except with a 12-inch open nipple in the streamward opening, the upstream outlet plugged.
33. Same as 23, except with a 12-inch capped nipple in the streamward opening, the downstream outlet plugged.
34. Same as 23, except with a 12-inch capped nipple in the streamward opening, the upstream outlet plugged.

STANDARD PIPE WITHOUT FITTINGS

35. 1-inch pipe with end cut square.
36. 1½-inch pipe with end cut square.
37. 2-inch pipe with end cut square.
38. 2½-inch pipe with end cut square.
39. 3-inch pipe with end cut square.
40. 4-inch pipe with end cut square.
41. 6-inch pipe with end cut square.

42. 3-inch pipe with end cut at an angle of 10°, and placed so that opening faced 10° upstream.
43. Same as 42, except with angle of 20°.
44. Same as 42, except with angle of 30°.
45. Same as 42, except with angle of 45°.

OTHER DEVICES

46. Kinnison intake box. A short airplane wing section set at a 6° negative angle of attack with the intake on the under side at the point of zero pressure.
47. Circular plate, 6 inches in diameter, with a 3-inch opening in center of plate.
48. Same as 47, except 12 inches in diameter.
49. Same as 47, except 18 inches in diameter.
50. Rectangular plate, 12 by 24 inches, with longer dimension horizontal, 3-inch intake at center.
51. Same as 50, except intake 6 inches downstream from center of plate.
52. Same as 51, except intake 6 inches upstream from center of plate.
53. Eisenlohr intake box. A casting resembling a 3-inch pipe compressed to a stream-line shape with a ½-inch by 15-inch intake slot on under side.
54. Palm funnel. A truncated right circular cone; large end 12 inches in diameter, pointing outward. Elements of cone form an angle of 45° with common axis of cone and pipe.
55. Sawyer sieve. A 3-inch pipe with end cut square; four rings of four holes ¾ inch in diameter; rings spaced 3 inches apart; holes to be as far from the open end of the pipe as practicable.
56. Concrete pier, 12 inches high and 24 inches long; intake near top at center of pier.
57. Same as 56, except with the top of the pier beveled downward at the upstream and downstream ends.
58. Standard 3-inch tee with outlet on the pipe; flow through the run.
59. Same as 58, except with a 12-inch nipple in each run.
60. Same as 58, except with a 12-inch nipple in the downstream run.
61. Same as 58, except with a 12-inch nipple in the upstream run.
62. Same as 58, with threads removed from the run.
63. Handrail tee with outlet on the pipe; flow through the run; threads removed from the run.
64. Same as 58, except with the run in a vertical position.
65. Long static tube of 3-inch pipe with cap on upstream end and connected to intake pipe by elbow at downstream end. Two rows of ¾-inch holes arranged with 8 holes each on top and bottom, holes beginning 3 pipe diameters from upstream end and ending 3 pipe diameters above downstream end. Tube pointing upstream.
66. Hanlon funnel. A cylinder 9 inches in diameter and 5½ inches long with a conical section on downstream end 4 inches long with downstream opening 6 inches in diameter; made of sheet metal. Side of cylinder attached to the intake pipe.
67. Twitchell baffle. A horizontal and a vertical vane of ⅛-inch sheet metal inserted in end of pipe, protruding 6 inches. Replaced by No. 72.
68. Same as 67 except vanes turned 45° from the vertical.
69. Prior intake. Two intake pipes with the intake on one pipe turned upstream and the intake on the other pipe turned downstream.
70. Canfield baffle. A flat plate 8 inches square, normal to current, held in position 3 inches upstream from end of pipe.

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71. Same as 70, except with the plate held in position on the downstream side of pipe.
72. Same as 67, except the vanes adjustable to protrude different distances from the end of the pipe.
73. Same as 65, except pointing downstream.
74. Ash baffle. Same as 72 without the horizontal vane.
75. Cast-iron strainer, Walworth catalog No. 88, figure 2270.
76. Same as 75, except pointing downstream.
77. Curtis sleeve. A 12-inch cylinder, 18 inches long and concentric with the intake pipe, with the end of the pipe at the center of the cylinder.
78. Twitchell sleeve. A sleeve 12 inches long concentric with the intake pipe, the end of the pipe at center of the sleeve. The sleeve 6 inches in diameter where it projects beyond the pipe, increasing to 7.4 inches in diameter at the end of the sleeve that encircles the pipe.
79. Short static tube of 3-inch pipe 14 inches long; end of tube closed by a plugged coupling; downstream end connected to pipe by an elbow. Two rows of eight holes, one row on top and one row on bottom of tube. Holes ¾ inch in diameter and spaced 1½ inches. Tube pointed upstream.
80. Same as 79, except normal to flow.
81. Same as 79, except elbow replaced by a standard tee with outlet on pipe and capped nipple in downstream run.
82. Same as 81, except nipple inserted between the static tube and the tee, with a vertical support to bed of stream at the downstream end of the static tube.
83. Same as 79, except tube pointing downstream.
84. Same as 81, except tube pointing downstream.
85. Rectangular plate 12 inches wide by 8 feet long; intake at center of plate.
86. Same as 85, except plate 6 feet long.
87. Same as 85, except plate 4 feet long.
88. Rectangular plate, 24 inches long, extending from 6 inches above the intake to the bed of the stream.
89. Static tube 9½ inches long, with four rings of ¾-inch holes, rings spaced 1½ inches apart, four holes in each ring. Holes staggered in alternate rings. Tube pointing downstream.
90. Static tube 18 inches long, with five rings of ¾-inch holes, rings spaced 1½ inches apart, two holes in each ring. Holes staggered in alternate rings. Tube pointing downstream.
91. Static tube, 18 inches long, with six rings of 9/16-inch holes, rings spaced 1⅛ inches apart, six holes in each ring. Holes staggered in alternate rings. Tube pointing downstream.

METHODS OF TESTS

With the large number of devices to be tested in the laboratory it was desirable that some method be used that did not require too much time for the testing of each device. It was therefore decided to do as much preliminary work as possible with small-scale models, and so far as possible to use models for which the proper-size pipe fittings would be readily available. A 1 : 8 ratio was selected as being adapted for use in the small flume, 10 inches wide, in the laboratory. Prior to the selection of this ratio it had been decided to use a 3-inch intake pipe as the full-size prototype for the standard of comparison. The

⅛-scale models, therefore, were made for intake pipes ⅜ inch in diameter. These models were mounted in a glass-sided flume 10 inches wide in such a manner that the effects of horizontal angles and vertical angles in the plane of the current could be studied. The intake devices were connected to a ⅛-scale model well by the ⅛-scale intake pipe. A standard static opening in the floor of the flume directly under the intake was connected to one of two glass manometer wells placed side by side. The other glass manometer was connected to the bottom of the model well. This arrangement was very effective in showing the amount of draw-down as indicated by the difference in the water levels in the two glass manometer wells. The heights of the water surfaces in the manometer wells were measured by a double-point gage having a point in each well. This was found to be more accurate than to make a direct reading of the height of the water surface in the flume with a point gage.

After the preliminary arrangements were completed and the ⅛-scale A model in readiness for the tests, the members of the laboratory committee tested all the A models for a velocity of 2.8 feet per second passing the intake, the velocity being measured by a pygmy current meter. This method of procedure provided a ready means of comparing the performances of the various intake devices.

Suggestions for eliminating draw-down have generally fallen into one of three groups—(1) reducing velocity and thereby reducing the draw-down; (2) using part of the velocity head to overcome the draw-down; and (3) straightening the flow to eliminate the effect of velocity. Tests of the A models showed that most of the devices for which the draw-down was less than half the velocity head were in the group that straightens the flow, and few of the other devices appeared to eliminate the draw-down to that extent.

LABORATORY EQUIPMENT FOR TESTS OF 1/8-SCALE MODELS

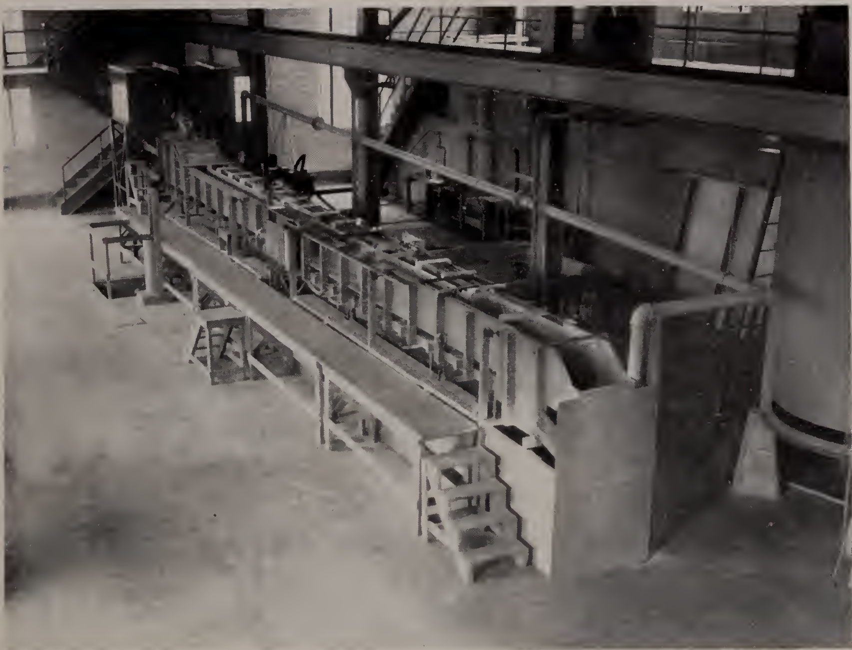
The small glass-sided flume shown in plate 28, *A*, had been narrowed from a width of 20 inches to a width of 10 inches by a longitudinal partition. This small flume was 35 feet long, and the models were tested about 13 feet upstream from the lower end of the flume. As it was desired to have the arrangement correspond to field conditions as nearly as possible, and the models to be tested were ⅛-scale, a model stilling well 7½ inches square was installed in the unused portion of the flume. This model of a stilling well 5 feet square was connected to the working half of the flume by a model of a 3-inch intake pipe consisting of 7/16 inch outside-diameter copper tubing. The outer end of this tubing was connected by a short length of rubber

tubing and a nipple to the rear of a ¼-inch brass coupling supported by a mounting block so that its center was 2⅞ inches above the floor of the flume and its front 3⅜ inches out from the wall of the flume. The models were then screwed into the front of this coupling. The coupling was soldered to the lower end of a vertical ¼-inch brass pipe clamped in the mounting block. The mounting block itself was merely a device for supporting the models at various horizontal and vertical angles as well as in the normal position. These arrangements are shown in plate 28, *B*.

Glass manometers mounted side by side on the outside wall of the flume as shown in plate 29, *A* and *B*, were arranged for connection to models in various positions. The manometer wells 2 inches in diameter at the left of the series of manometers were used in obtaining comparative heights of water in the model well and in the flume at the intake. The left one of the manometers was connected to the bottom of the stilling well. The right-hand manometer could be connected to any one of several standard static openings in the floor along the center line of the working part of the flume, an opening in the same section as the coupling supported by the mounting block being used, except for those devices which by their form of construction interfered with the static water pressure at that point or conveyed the water into the stilling well from a different section of the flume. These openings were about 0.17 foot apart near the intake. The positions of the water surfaces in the two manometer wells were measured by a double-point gage having a point operating in each well. The heights of the water surface in the flume and in the stilling well could also be measured directly by a point gage mounted on a movable frame that spanned the sides of the flume. However, the fluctuations in the water surface in the flume made it difficult to obtain accurate readings by this method. The maximum capacity of the flume was about 1.75 second-feet. The flow was measured by a rectangular weir in the return channel under the flume. This weir had been fully calibrated for previous projects in the flume and was not recalibrated for this work. The velocity in the flume at the intake was measured with a pygmy current meter.

THE A MODELS

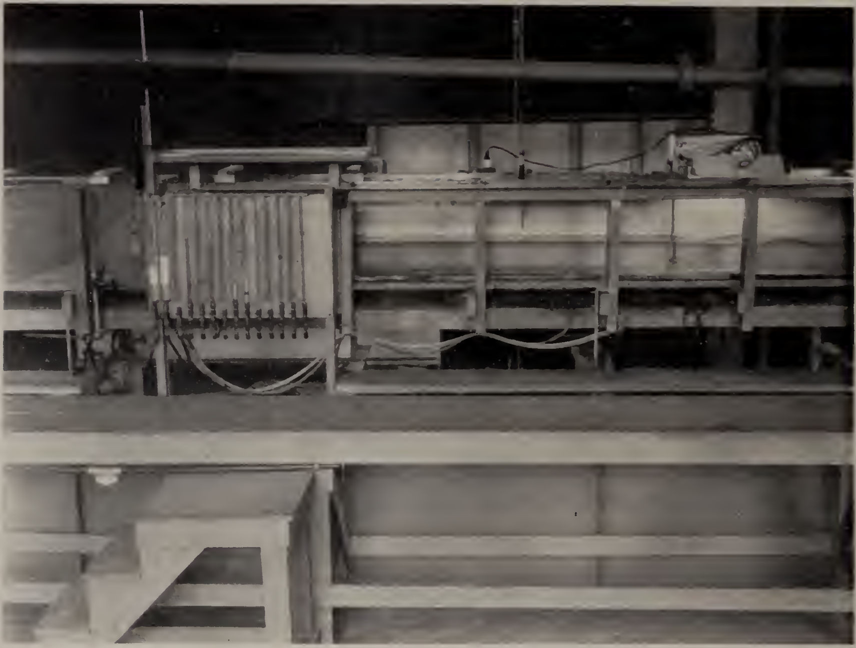
The series of ⅛-scale models to be tested in the small flume was designated the "A series." The dimensions of these models were not all exactly one-eighth the corresponding dimensions of the prototypes, but they were made as nearly to that scale as was practicable by the use of standard sizes of pipe, the dimensions of which were as shown in the following table:



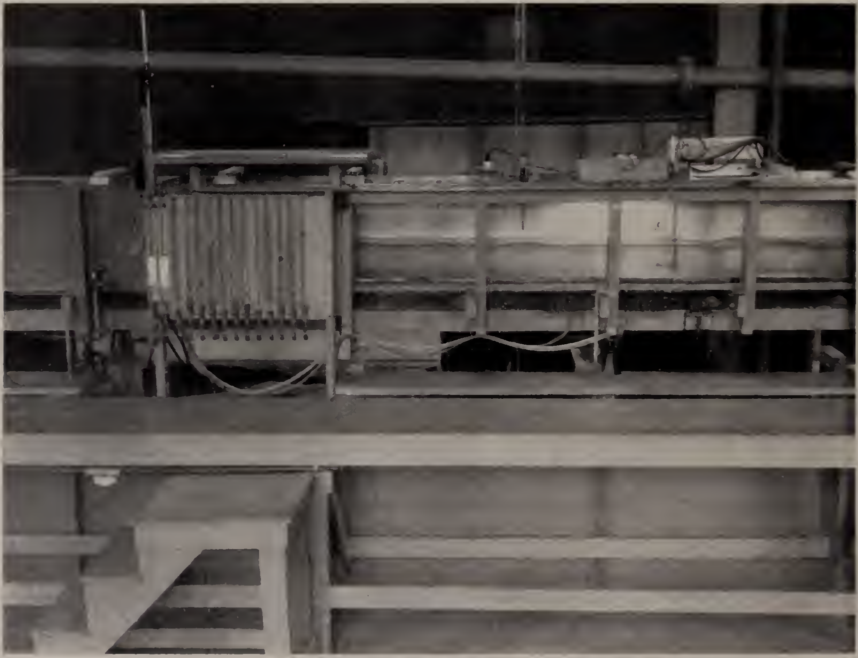
A. FLUME USED IN TESTS OF THE A MODELS.

B. MODEL GAGE WELL, MOUNTING BLOCK, AND SUPPORT, WITH MODEL A-39 POSITION FOR TEST.

Static openings in floor of flume.



A. DRAW-DOWN IN MANOMETER WELLS UNDER THE POINT GAGES IN TEST OF MODEL A-39.



B. TESTS OF MODEL A-79 UNDER A VELOCITY OF 2.8 FEET PER SECOND.

Manometer wells indicate practically no draw-down in this test.

TABLE 2.—*Dimensions of standard sizes of pipe*

Nominal diameter (inches)	Actual diameter (inches)	
	Inside	Outside
1/8	0.269	0.405
1/4	.364	.540
3/8	.493	.675
1/2	.622	.840
3/4	.824	1.050
1	1.049	1.315
2	2.067	2.375
2½	2.469	2.875
3	3.068	3.500
4	4.026	4.500

NOTE.—The 7/16-inch outside-diameter copper tubing that was used in some of the connections had and inside diameter of 0.354 inch.

An examination of the table of dimensions of standard sizes of pipe shows that the inside diameter of the ¼-inch pipe is very nearly one-eighth the inside diameter of the 3-inch pipe. Therefore ¼-inch brass pipe was generally used for the models, although the outside diameter did not correspond to the scale ratio. Standard fittings were used where needed. These fittings did not have the correct outside diameter for the scale ratio, but their shape was made to correspond to that of the prototype.

Tests of ⅛-scale models were made for nearly all the devices that had been suggested by the district engineers. A few devices were of such shape that ⅛-scale models could not be made conveniently, and tests of those devices were made with full-size "P" models without the preliminary tests at ⅛-scale. A list of the A models actually tested and their dimensions is given in the following table:

TABLE 3.—*Dimensions of A models*

Model No.	
A–35 to A–41	True to scale.
A–42 to A–45	¼-inch pipe.
A–1 to A–6	¼-inch pipe fittings, outside shaped to form of prototype.
A–7 to A–14, A–16 to A–18	All ¼-inch pipe fittings except that tee and nipple cap had outside shaped to form of prototype.
A–19 to A–22	¼-inch pipe fittings, outside shaped to form of prototype.
A–23 to A–34	All ¼-inch pipe fittings except that the cross and the nipple cap had outside shaped to form of prototype.
A–46 to A–51	True to scale, connected by ⅛-inch pipe.
A–54	True to scale, connected by ¼-inch pipe.
A–55	¼-inch pipe 2¼ inches long with four rings of 3/32-inch holes, four holes in each ring.
A–58 to A–64	¼-inch tee, outside shaped to form of prototype.
A–65, A–73	¼-inch pipe and fittings, outside of cap shaped to form of prototype.
A–66 to A–67	True to scale, on ¼-inch pipe.
A–70	True to scale, on ⅛-inch pipe.
A–72, A–74, A–77	True to scale, on ¼-inch pipe.

Table 3.—*Dimensions of A models*—Continued

Model No.	
A–78, A–83	1/8-inch pipe and fittings. Pipe capped instead of having plugged coupling, but cap is very close to scale model of coupling, as it is made of stamped metal instead of being cast.
A–85 to A–88	True to scale, 1/4-inch pipe connections.

All the models listed above were tested in the normal position and in addition they were usually tested at angles of 5° and 10° in both directions from the normal position in either a horizontal plane or a vertical plane or both in the direction of flow. Some models were also tested at horizontal angles of 15° and 20°.

All the models were tested under the same velocity of 2.8 feet per second. In table 4, which shows the results of the tests, the models are listed in the order of best performance in the normal position. Only the most favorable observation is shown where more than one observation was made. The performance of some models in the normal position gives them a more favorable position in the list than is warranted by their performance under conditions of angularity. From a study of those tests 17 models were selected for further investigation at velocities of 1.0, 2.0, and 3.65 feet per second. Model A–39, a 3-inch pipe cut square, was also included for comparison. The results of the tests of the selected A models under the various velocities are given in table 5. The depth of water in the flume varied between 0.55 and 0.65 foot.

The velocity at the intake for each setting of the flow in the flume was measured with a cup-type pygmy current meter that had previously been rated in the current-meter rating flume of the National Bureau of Standards. The meter could not be placed exactly at the intake, owing to the pipe connections, but was used 0.25 foot upstream from the center of the intake.

The static opening at the mounting block was used for all models except A–65, A–73, A–79, A–83, and A–88. For models A–65 and A–79 the opening 0.17 foot upstream was used, and for A–73 and A–83 the opening 0.17 foot downstream was used. As model A–88 extended to the floor of the flume, no static opening in the immediate vicinity of the model could be accepted as giving a true indication of the height of water in the flume. Therefore a static opening about 8 inches upstream was used. As this model filled a large portion of the cross section when it was turned to the usual horizontal angles, the results obtained under those conditions may not have been truly representative of its performance in a natural channel.

TABLE 4.—*Results of tests of A models under a velocity of 2.8 feet per second*

[Models listed in order of best performance in normal position. Where there was more than one observation the best observation is listed. There was a slight variation in the velocity]

Model		Difference, in feet, in elevation of water surface in well from that in flume									
		Horizontal angle					Vertical angle				
No.	Name [1]	−10°	−5°	0	+5°	+10°	10°	−5°	0	+5°	+10°
A-65	Static tube pointing upstream	−0.011	−0.004	0.0	0.002	−0.001	0.0	0.0	0.0	0.0	0.0
A-73	Static tube pointing downstream	−.003	.0	.0	−.002	−.011	−.007	−.001	.0	−.003	−.007
A-81	Short static tube	−.011	−.002	.002	.005	.004	.0	.002	.002	−.003	−.001
A-74	Ash baffle (projecting 0.44 inch on the A model)[2]	−.013	−.008	−.002	.0	.005	−.005	−.004	−.002	−.004	−.003
A-72	Twitchell baffle (projecting 0.56 inch on the A model)	−.020	−.013	−.002	.005	.014	.010	−.004	−.002	−.005	−.004
A-58	3-inch tee	−.052	−.028	−.004	.0	.011	−.029	−.018	−.004	−.032	−.020
A-79	Short static tube	−.011		.005		.008					
A-84	Static tube with tee connection	−.005	.003	.006	.004	.0	.003	.004	.006	.002	.001
A-87	Rectangular plate 1 by 4 feet	−.024	−.012	−.007	−.001	006					
A-50	Rectangular plate 1 by 2 feet	−.018	−.008	−.008	−.005	.001					
A-85	Rectangular plate 1 by 8 feet	−.030	−.019	−.008	−.002	.002	−.014	−0.10	−.008	−.009	−.010
A-86	Rectangular plate 1 by 6 feet	−.027	−.017	−.009	−.005	.004	−.011	−.010	−.009	−.013	−.011
A-49	Circular plate, 18 inches in diameter	−.029	−.023	−.014	−.010	.0					
A-51	Rectangular plate 1 by 2 feet	−.030	−.020	−.014	−.009	−.003					
A-44	3-inch pipe cut at 30° angle	−.072	−.047	−.016	.009	.041					
A-52	Rectangular plate 1 by 2 feet	−.059	−.035	−.018	−.002	−.001					
A-48	Circular plate 12 inches in diameter	−.036	−.023	−.030	−.011	−.002					
A-88	Rectangular plate 24 inches long extending to bed of flume	−.079	−.032	−.032	−.018	−.005					
A-59	3-inch tee with 12-inch nipple in each run			.033							
A-26	4-way cross, horizontal, streamward outlet plugged	−.065	−.055	−.036	−.026	−.024	−.049	−.047	−.036	−.048	−.046
A-46	Kinnison box (not an exact model) [3]	−.064		−.039		−.030	−.043	−.040	−.039	−.038	−.040
A-46	do.[4]	−.055	−.052	−.042	−.033	−.032	−.043	−.043	−.042	−.040	−.041
A-13	3-inch tee with run on intake, 12-inch nipple in outlet pointing upstream						.039	.043	.042	.042	.040
A-68	Twitchell baffle with vanes rotated 45°			−.042							
A-11	3-inch tee with run on intake, outer end of run plugged, outlet downstream						−.094	0.094	−.048	−.065	−.080
A-45	3-inch pipe cut at 45° angle	.016	.037	.050	.065	.085					
A-24	4-way cross, horizontal, downstream outlet plugged						.025	.066	.052	.068	.066

[1] The descriptions are intended to refer to the full-size models for which the A models were constructed at a 1:8 ratio.
[2] Baffle in end of model A-39.
[3] Model casting smoothed and polished.
[4] Model as cast.

TABLE 4.—*Results of tests of A models under a velocity of 2.8 feet per second*—Continued

Model		Difference, in feet, in elevation of water surface in well from that in flume									
		Horizontal angle					Vertical angle				
No.	Name	−10°	−5°	0	+5°	+10°	10°	−5°	0	+5°	+10°
A-4	45° elbow pointing upstream						0.068	0.069	0.059	0.070	0.068
A-7	3-inch tee with run on intake, outlet upstream						.064	.072	.062	.069	.060
A-30	4-way cross, 12-inch capped nipple on downstream outlet								−.062		
A-28	4-way cross, downstream outlet open, other outlets plugged						−.080	−.080	−.063	−.070	−.078
A-61	3-inch tee, outlet on intake, 12-inch nipple on upstream run			−0.065							
A-34	4-way cross, 12-inch capped nipple in streamward outlet, upstream outlet plugged								−.067		
A-2	90° elbow pointing downstream						−.079	−.073	−.068	−.075	−.078
A-43	3-inch pipe cut at 20° angle	−0.124	−0.100	−.070	−0.043	−0.011					
A-71	Canfield baffle			−.072							
A-23	4-way cross, horizontal, all outlets open	−.094	−.088	−.075	−.073	−.055	−.082	−.081	−.075	−.077	−.082
A-60	3-inch tee, outlet on intake, 12-inch nipple in downstream run			.078							
A-17	3-inch tee with 12-inch capped nipple in run, outlet downstream						−.075	−.074	−.078	−.074	−.076
A-29	4-way cross with 12-inch nipple in streamward outlet								−.079		
A-66	Hanlon funnel	.060	.073	.083	.093	.110	.085	.085	.083	.084	.082
A-32	4-way cross with 12-inch nipple in streamward outlet, upstream outlet plugged								−.084		
A-77	Curtis sieve	−.079	−.088	−.086	−.092	−.087					
A-14	3-inch tee with 12-inch nipple outlet pointing downstream						−.107	−.092	−.086	−.088	−.093
A-47	Circular plate, 6 inches in diameter								−.086		
A-25	4-way cross with upstream outlet plugged						−.096	−.094	−.096	−.089	−.096
A-31	4-way cross with 12-inch nipple in streamward outlet, downstream outlet plugged								.096		
A-70	Canfield baffle			−.097							
A-54	Palm funnel	−.127	−.114	−.098	−.075	−.043					
A-8	3-inch tee with outlet downstream						−.124	−.115	−.100	−.102	−.117
A-5	45° elbow pointing downstream						−.111	−.108	−.108	−.105	−.106
A-55	Sawyer sieve			−.111							
A-10	3-inch tee with outlet upstream, outer end of run plugged						.138	.138	.115	.139	.133
A-21	4-inch to 3-inch reducing coupling	−.157	−.145	−.122	−.102	−.075					
A-27	4-way cross with upstream outlet open, other outlets plugged								.126	.141	
A-18	3-inch tee with 12-inch capped nipple on run, outlet downward						−.116	−.119	−.126	−.129	−.118
A-16	3-inch tee with 12-inch capped nipple on run, outlet upstream						.140	.135	.126	.135	.137
A-42	3-inch pipe cut at 10° angle	−.161	−.148	−.129	−.097	−.065					
A-64	3-inch tee with outlet on intake, run in vertical position								−.130		
A-33	4-way cross with 12-inch capped nipple in streamward outlet, upstream outlet plugged								.134		

A-3	90° elbow pointing downward						−.157	−.143	−.135	−.121	−.106
A-1	90° elbow pointing upstream						.135	.135	.135	.138	.137
A-6	45° elbow pointing downward						−.148	−.138	−.136	−.120	−.109
A-12	3-inch tee with outlet pointing downward, outer end of run plugged						−.141	−.144	−.136	−.130	−.116
A-20	3-inch to 2-inch reducing elbow, with 2-inch opening pointing downward						−.159	−.147	−.141	−.128	−.110
A-19	4-inch to 3-inch reducing elbow with 4-inch opening pointing downward						−.150	−.146	−.142	−.114	−.097
A-9	3-inch tee with outlet pointing downward						−.130	−.136	−.148	−.138	−.135
A-40	4-inch pipe cut square	.112	−.145	−.157	−.139	−.116					
A-37	2-inch pipe cut square	−.153	−.150	−.157	−.157	−.129					
A-39	3-inch pipe cut square	−.128	−.166	−.164	−.150	−.121					
A-22	3-inch to 2-inch reducing coupling with 3-inch end on intake	−.159	−.161	−.164	−.145	−.120					
A-38	2½-inch pipe cut square	−.150	−.161	−.165	−.159	−.129					

TABLE 5.—*Tests of selected A models under various velocities*

STRAIGHT PIPE [1]

A-39. 3-inch pipe cut square

Velocity at intake (feet per second)	Difference, in feet, in elevation of water surface in well from that in flume													
	Horizontal angle									Vertical angle				
	−20°	−15°	−10°	−5°	0	+5°	+10°	+15°	+20°	−10°	−5°	0	+5°	+10°
1.0					−0.019									
2.0					−.082									
2.8			−0.128	−0.166	−.164	−0.150	−0.121							
3.65					−.253									

STATIC TUBES

A-65. Long static tube pointing upstream

Velocity at intake (feet per second)	−20°	−15°	−10°	−5°	0	+5°	+10°	+15°	+20°	−10°	−5°	0	+5°	+10°
1.0			−0.002	0	0	0	0							
2.8			−.011	−.004		.002	−.001			0	0	0	0	0
3.65			−.026	−.010	.003	.007	.003							

A-73. Long static tube pointing downstream

Velocity at intake (feet per second)	−20°	−15°	−10°	−5°	0	+5°	+10°	+15°	+20°	−10°	−5°	0	+5°	+10°
1.0			−0.001	−0.001	−0.001	−0.002	−0.002							
2.8			−.003	0	0	−.002	−.011			−0.007	−0.001	0	−0.003	−0.007
3.65			−.010	−.007	−.013	−.013	−.026							

A-79. Short static tube pointing upstream

Velocity at intake (feet per second)	−20°	−15°	−10°	−5°	0	+5°	+10°	+15°	+20°	−10°	−5°	0	+5°	+10°
1.0			−0.002	−0.001	0	0.001	0.001							
2.0			−.006	−.002	.002	.004	.004							
2.8	−0.034	−0.024	−.001		.005		.008	−0.005	−0.001					
2.8 [2]			−.011	−.002	.002	.005	.004			0	0.002	0.002	−0.003	−0.001
3.65	−.026	−.043	−.026	.007	0	−.007	0	−.003	−.007	.003	−.007	0	0	−.010

A-83. Short static tube pointing downstream

1.0			−0.002	−0.001	−0.001	−0.001	−0.002							
2.0			−.007	−.004	−.004	−.005	−.008							
2.8 [3]			−.005	.003	.006	.004	0			0.003	0.004	0.006	0.002	0.001
3.65			−.026	−.013	−.006	−.003	−.020							

FLAT PLATES

A-49. Circular plate 18 inches in diameter [4]

1.0			−0.003	−0.002	−0.002	−0.002	0	0.001	0.003					
2.0			−.012	−.011	−.008	−.005	0	.006	.011					
2.8			−.029	−.023	−.014	−.010	0	.011	.028					
3.65			−.036	−.020	−.013	−.003	.023	.033	.052					

A-50. Rectangular plate 1 by 2 feet

1.0			−0.002	−0.002	−0.002	−0.001	−0.001	0	0.002					
2.0			−.008	−.008	−.004	−.002	.001	.004	.011					
2.8			−.018	−.008	−.008	−.005	.001	.009	.021					
3.65			−.023	−.013	−.010	0	.013	.033	.043					

A-87. Rectangular plate 1 by 4 feet [4]

1.0			−0.003	−0.002	−0.001	0	0.001	0.002	0.003					
2.0			−.011	−.006	−.002	.001	.004	.011	.016					
2.8			−.024	−.012	−.007	−.001	.006	.016	.030					
3.65			−.030	−.016	−.007	−.003	.016	.036	.045					

A-86. Rectangular plate 1 by 6 feet [4]

1.0			−0.004	−0.002	−0.001	−0.001	0.001	0.001	0.004					
2.0			−.014	−.007	−.003	−.001	.003	.009	.015					
2.8			−.027	−.017	−.009	−.005	.004	.013	.024	−0.011	−0.010	−0.009	−0.013	−0.011
3.65			−.046	−.026	−.013	0	.010	.023	.046					

[1] For purposes of comparison.
[2] Data for model A-81.
[3] Model A-84 used at 2.8 feet per second.
[4] Normal position parallel with direction of flow; intake at center of plate.

TABLE 5.—*Tests of selected A models under various velocities*—Continued

FLAT PLATES—Continued

A-85. Rectangular plate 1 by 8 feet [5]

Velocity at intake (feet per second)	Difference, in feet, in elevation of water surface in well from that in flume													
	Horizontal angle									Vertical angle				
	−20°	−15°	−10°	−5°	0	+5°	+10°	+15°	+20°	−10°	−5°	0	+5°	+10°
1.0			−0.004	−0.002	−0.001	0	0.001	0.002	0.004					
2.0			−.015	−.009	−.003	0	.003	.010	.017					
2.8			−.030	−.019	−.008	−.002	.002	.010	.027	−.014	−.010	−.008	−.009	−.010
3.65			−.043	−.020	−.010	.007	.016	.036	.062					
A-51. Rectangular plate 1 by 2 feet, intake 6 inches downstream from center														
1.0			−0.003	−0.003	−0.002	−0.002	−0.001	0	0.001					
2.0			−.014	−.012	−.008	−.006	−.002	.001	.006					
2.8			−.030	−.020	−.014	−.009	−.003	.004	.013					
3.65			−.036	−.030	−.020	−.010	.016	.030	.036					
A-88. Rectangular plate 2 feet long, bottom on bed of stream, top 6 inches above intake														
1.0			−0.011	−0.006	−0.004	−0.004	−0.002	−0.001	−0.001					
2.0			−.042	−.021	−.014	−.010	−.006	−.002	0					
2.8			−.079	−.032	−.032	−.018	−.005	.012	.026					
3.65			−.092	−.049	−.040	−.030	−.013	.003	.013					
BAFFLES														
A-67. Twitchell baffle, original model														
1.0			0	0.001	0.001	0.001	0.002							
2.0			−.004	.001	.007	.005	.006							
2.8			.004	.012	.012	.018	.019							
3.65			−.003	.013	.026	.036	.026							

A-72. Twitchell baffle, 0.56 inch projecting from pipe

1.0			−0.004	−0.003	−0.002	−0.001	−0.001							
2.0			−.014	−.010	−.004	.001	.005							
2.8	−0.037	−0.032	−.020	−.013	−.002	.005	.014	0.016	0.018	−0.010	−0.004	−0.002	−0.005	−0.004
3.65	−.046	−.020	−.020	−.010	.023	.016	.020	.039	.046	−.010		.023		0

A-74a. Ash baffle, 0.38 inch projecting from pipe [5]

1.0			−0.003	−0.003	−0.001	0	0							
2.0			−.007	−.005	−.001	.003	.005							
3.65			−.016	−.007	.003	.013	.020							

A-74b. Ash baffle, 0.44 inch projecting from pipe

1.0			−0.001	−0.001	−0.001	0	0.001							
2.0			−.007	−.005	−.001	0	.003							
2.8			−.013	−.008	−.002	0	.005			−0.005	−0.004	−0.002	−0.004	−0.003
3.65			−.016	−.007	−.003	.010	.020							

MISCELLANEOUS

A-46. Kinnison box

1.0			−0.008	−0.007	−0.006	−0.005	−0.004							
2.0			−.027	−.023	−.023	−.022	−.020							
2.8			−.064		−.039		−.030			−0.043	−0.040	−0.039	−0.038	−0.040
3.65			−.075	−.062	−.059	−.052	−.043			−.072	−.062	−.059	−.056	−.052

A-58. 3-inch tee, flow through run

1.0			−0.006	−0.003	−0.002	−0.001	−0.001							
2.0			−.026	−.013	.001	.008	.009							
2.8			−.052	−.028	−.004	0	.011			−0.029	−0.018	−0.004	−0.032	−0.020
3.65			−.085	−.033	−.003	.016	.016							

[4] Normal position parallel with direction of flow, intake at center of plate.

[5] At 2.8 feet per second with projection of 0.38-inch but with total length of 1.07 inches the difference for zero angle was −0.010 on model A-69, which was slightly longer than A-62.

FULL-SIZE MODELS

The 47 full-size models that were selected for tests are listed on pages 56–58. The Eisenlohr box and the Walworth strainer were tested at full size without previous tests on 1:8 scale models, as their construction was such that they could not be accurately built at the 1:8 scale. The full-size models of the devices for use with 3-inch intake pipes, sometimes called the "prototypes," were given the same serial numbers as the corresponding models at the 1:8 ratio but were distinguished from the small models by the use of the prefix P, the prefix A having been used with the same serial numbers for the small models.

Full-size models of devices for use with various sizes of intake pipes were given the following designations:

H, models for 1-inch pipe.
K, models for 1½-inch pipe.
L, models for 2-inch pipe.
M, models for 2½-inch pipe.
P, models for 3-inch pipe.
Q, models for 4-inch pipe.

APPARATUS USED IN TESTS OF THE FULL-SIZE MODELS

In order to make tests of the full-size models under velocities that would be comparable with those obtained in the 10-inch flume in the tests of the A models, a temporary timber flume 3 feet in width was constructed in the center of the 12-foot flume. (See pl. 30, A.) This 3-foot flume was 47 feet in length and was open at both ends. The sides at the upper end were curved outward to form a bell-shaped entrance, which extended 43 inches upstream beyond the straight part of the 3-foot flume. A 14-inch opening between the upper end of the bell-shaped entrance and the side wall of the 12-foot flume on each side admitted water to the 4.5-foot spaces on the two sides of the 12-foot flume. These outer 4.5-foot spaces were closed by temporary bulkheads opposite the lower end of the 3-foot flume, as shown in plate 30, A. Under this arrangement static water pressure was maintained on the outside of the 3-foot flume, although all the flow was carried by that flume. The height of water in the flume was controlled by needle gates 25 feet downstream. These needle gates were set so as to maintain a depth of 3 feet for all tests of the full-size models.

The exact height of water in the flume was measured by means of piezometer gages outside the flume wall connected to static openings in the floor of the flume. The static openings could also be separately connected to a stilling well equipped with a hook gage. The piezometers and the gage well are shown in plate 30, *B*. Static opening No. 1 was in the center of the flume 2 feet downstream from the intake connection, static opening No. 2 was in the center of the flume

opposite the end of the intake pipe, and static opening No. 3 was in the center of the flume 2 feet upstream from the intake.

An intake pipe 3 inches in diameter passed through the side wall of the 3-foot flume and was placed so that the device under test when in a horizontal position would be in the center of the flume and 6 feet above its lower end. The outer end of the 3-inch intake pipe was connected to the outlet of a 3-inch tee, which in turn was screwed to the top of a 3-inch riser pipe but was easily turned for obtaining horizontal angles by means of a ¾-inch pipe handle connected to the top run of the tee by means of reducers. The pipe handle was extended to an opening in the wall of the 12-foot flume so that the settings for the various horizontal angles could be made from outside the flume.

The device under test could be tilted to various vertical angles by turning the intake pipe in the tee connection, the angle of tilt being indicated by a pointer.

From the riser pipe at the outer end of the 3-inch intake pipe a 1-inch pipe connection led to the same stilling well used for the connections to the static openings. Valves in each line permitted individual connections to be made to any one of the static openings and to the 3-inch intake pipe. Because of the pulsations in the water and the corresponding variations in the static head measured in the stilling well, the hook gage was replaced by a water-stage recorder (see pl. 30, *B*) having a height ratio of 5 : 12 (1 inch=0.2 foot) and a time scale of about 3.6 inches an hour. The continuous records of stages permitted average heights to be determined to the nearest 0.001 or 0.002 foot.

As there was only one stilling well for use in obtaining comparative readings of stages indicated by the intake and by the static opening in the floor of the flume, the readings being taken individually by the use of valves on the connection pipes, it was essential that no change in flow should occur between the times of taking the two readings. The use of the water-stage recorder permitted any changes in stage corresponding to changes in flow to be detected. Several observations were repeated because of slight changes in stage.

DISTRIBUTION OF VELOCITY IN THE 3.0-FOOT FLUME

The tests of the various intake devices were made with a depth of water of 3.0 feet in the 3.0-foot flume, the intake being placed so that the device was at the center of the flume. With a flow of 27 second-feet in the flume and the needle gates set to maintain a depth of 3.0 feet, the velocity at the end of the intake pipe was about 2.8 feet per second. The distribution of the velocity in the flume as determined from measurements made with a pygmy current meter is shown in figure 4.

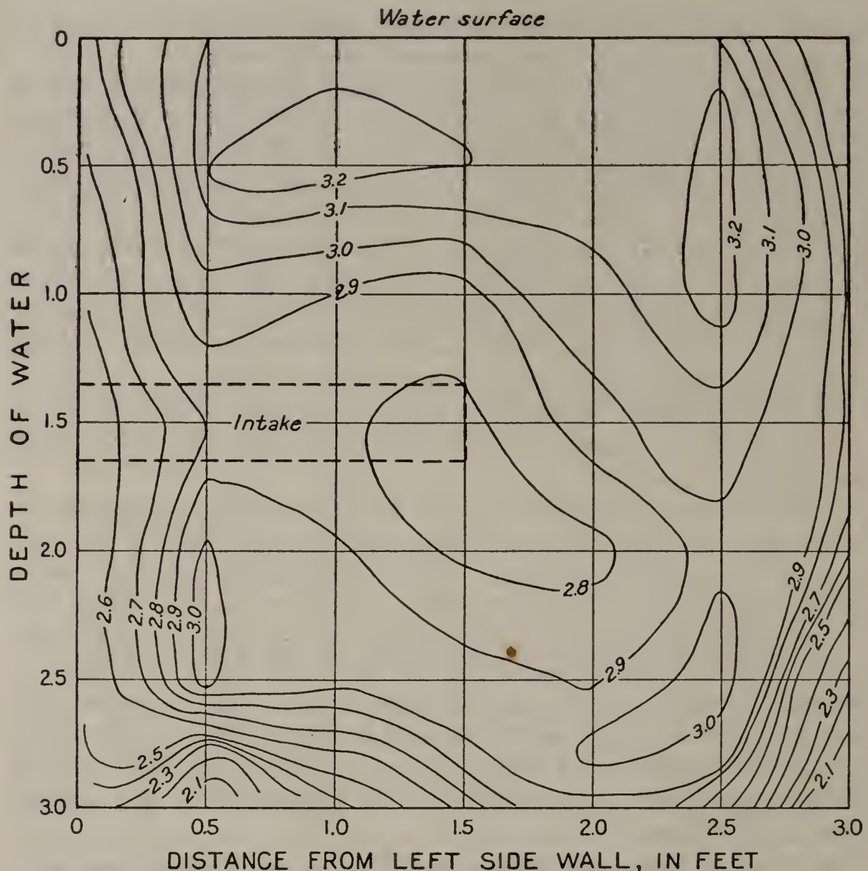


FIGURE 4.—Distribution of velocity in the 3-foot flume for a velocity of 2.8 feet per second at the intake.

MODELS SELECTED FOR TESTS

The models selected for the full-size tests corresponded to those which gave good results under the tests of ⅛-scale A models in the 10-inch flume. A few full-size models were tested without previous tests having been made at the ⅛-scale. Tests of intakes pipe with the ends cut square were made for purposes of comparison. The full-size models that were selected for tests are listed below.

TABLE 6.—*Full-size models selected for tests*

Model No.	
H-35	1-inch pipe with end cut square.
K-36	1½-inch pipe with end cut square.
L-37	2-inch pipe with end cut square.
M-38	2½-inch pipe with end cut square.
P-39	3-inch pipe with end cut square.
Q-40	4-inch pipe with end cut square.

TABLE 6.—*Full-size models selected for tests*—Continued

Model No.	
P–46	Kinnison box with 6-inch nipple and cap at outer end.
M–49a	Circular plate, 16 inches in diameter, attached to 2½-inch intake.
P–49a	Circular plate, 16 inches in diameter, attached to 3-inch intake.
P–50	12- by 24- by $\frac{3}{16}$-inch steel plate, long dimension horizontal, intake at center.
P–53	Eisenlohr box, 6 by 20 inches, stream-lined, intake slot half an inch by 15 inches.
L–58, M–58, P–58	Stock tees, outlet on intake pipe, flow through run.
L–58a, M–58a, P–58a	Stock tees, same as above except that threads were removed from run to make it of uniform diameter.
L–58b	Handrail tee, threads removed from run.
L–72, M–72, P–72, Q–72.	Twitchell baffle, vertical and horizontal vanes one-eighth of an inch thick held in position in models L–37, M–38, P–39, and Q–40, respectively, by set screws near outer end. Lengths as shown in table 8.
L–74, M–74, P–74, Q–74.	Ash baffle, vertical vane one-eighth of an inch thick held in position in models L–37, M–38, P–39, and Q–40. Lengths as shown in table 8.
P–75	Walworth cast-iron strainer, catalog No. 88, pointing straight out, normal to direction of flow.
P–76	Walworth cast-iron strainer, same as P–75 except pointing downstream.
L–79	Static tube, 2 inches in diameter, 14 inches long, eight holes half an inch in diameter spaced 1½ inches apart top and bottom. Tube pointing upstream.
M–79	Static tube, 2½ inches in diameter, 17½ inches long, eight holes five-eighths of an inch in diameter spaced 1⅞ inches apart top and bottom. Tube pointing upstream.
P–79	Static tube, 3 inches in diameter, 13¾ inches long, eight holes three-quarters of an inch in diameter spaced 1½ inches apart top and bottom. Tube pointing upstream.
P–80	Static tube, same as P–79 except pointing straight out; normal to direction of flow.
L–83, M–83, P–83	Static tubes, same as L–79, M–79, and P–79 except pointing downstream.
P–88	Steel plate, same as P–50 except that another 12- by 24- by $\frac{3}{16}$-inch plate was attached below P–50 so that the total height was 24 inches. Intake in center of upper plate.
P–89	Static tube, 3 inches in diameter, 9½ inches long, four rings of four holes three-quarters of an inch in diameter, rings spaced three-quarters of an inch apart.
P–90	Static tube, 3 inches in diameter, 18¾ inches long, five rings of two holes three-quarters of an inch in diameter, rings spaced 1½ inches apart.
P–91	Static tube, 3 inches in diameter, 18⅝ inches long, six rings of six holes nine-sixteenths of an inch in diameter, rings spaced 1⅛ inches apart.

Table 6.—*Full-size models selected for tests*—Continued

Model No.	
P–92	Static tube, 3 inches in diameter, 18¾ inches long, five rings of six holes nine-sixteenths of an inch in diameter, rings spaced 1⅛ inches apart.
P–93	Static tube, 3 inches in diameter, 19 inches long, five rings of four holes three-quarters of an inch in diameter, rings spaced 1½ inches apart.
P–94	Static tube, 3 inches in diameter, 13 inches long, five rings of four holes three-quarters of an inch in diameter, rings spaced 1 inch apart.
P–95	Static tube, 3 inches in diameter, 12½ inches long, outer end closed by plug with hemispherical nose instead of standard coupling and plug; arrangement of holes same as in P–94.
P–96	Static tube, same as P–93 except that length of tube between couplings was 18 inches.
P–97	Static tube, same as P–94 except that length of tube between couplings was 12 inches.
P–98	Static tube, same as P–95 except that length of tube was 12 inches.
L–99	Static tube, 2 inches in diameter, 12 inches long, 5 rings of 4 holes ½ inch in diameter, rings spaced 1 inch apart.

TESTS

In the tests of the full-size models each device that was to be tested was attached to the outer end of the intake pipe by means of a coupling, or a coupling and elbow, so that the intake opening would be in the center of the 3-foot flume, or as nearly in the center as it could be placed. The models were all tested in a level position, with the device pointing in the direction in which it was intended to be used. In addition to the tests of the models in the normal position, tests were also made with the models turned through horizontal angles of +5° +10°, −5°, and −10°; and for similar vertical angles. The horizontal angles were designated "plus" for a movement in the clockwise direction from the position in which the intake was intended to be used, and "minus" for a counterclockwise movement. Vertical angles were designated "plus" if the movement was upward from the normal position and "minus" if downward. The effects of angularity were studied in order to obtain information regarding the relative performance of the various devices if the direction of flow was at an angle with the intake.

All the models were tested for the same velocity of water in the flume, which was 2.8 feet per second immediately in front of the intake when the mean velocity in the flume was 3.0 feet per second. (See fig. 4.) The corresponding discharge was 27 second-feet, which

was as much as could be obtained for continuous use from the pumps that were available.

Static opening No. 2, immediately under the intake, was generally used in the determination of the height of water in the flume, but for the static tubes pointing downstream the average of heights for openings Nos. 1 and 2 was used, and for static tubes pointing upstream the average for openings Nos. 2 and 3 was used, as for these positions of the static tubes the openings in the tubes were between the two static openings in the flume.

A considerable number of the models that gave favorable results under the tests at 2.8 feet per second were subsequently tested for a velocity of 2.0 feet per second. The results of the tests for both of these velocities are given in table 7.

A comparison of the results of the tests of full-size models of devices for use with different sizes of pipe, including the static tubes, the Ash and Twichell baffles, the circular plate, the tee connections, and the straight pipe with end cut square, are given in table 8. The tests shown in this table were all for the same velocity of 2.8 feet per second. The correct lengths of the Ash and Twichell baffles for use with different sizes of pipes were determined by experiment. The results of the experimental tests for determining the correct lengths are given in table 9.

TABLE 7.—*Tests of full-size models of 3-inch intake devices*

Model		Velocity (feet per second)	Difference, in feet, in elevation of water surface in well from that in flume									
			Horizontal angle					Vertical angle				
No.	Name		−10°	−5°	0	+5°	+10°	10°	5°	0	+5°	+10°
	STATIC TUBES [1]											
P-79	13¾-inch static tube pointing upstream	2.0	−0.009		0.005		0.002	0.003		0.005		0
		2.8	−.020	−0.006	.004	0.006	.008	.001	0.003	.004	0.003	.003
P-83	13¾-inch static tube pointing downstream	2.0	−.008		−.002		−.008	−.004		−.002		−.004
		2.8	−.013	−.008	−.004	−.006	−.013	−.008	−.008	−.004	−.010	−.008
P-89	9½-inch static tube pointing downstream	2.0	−.006		−.003		−.002	−.006		−.003		−.008
		2.8	−.011	−.004	−.002	−.003	−.005	−.011	−.006	−.002	−.006	−.011
P-90	18¾-inch static tube pointing downstream	2.0	−.005		−.003		−.008	−.005		−.003		−.006
		2.8	−.002	−.007	−.004	−.005	−.002	−.009	−.004	−.004	−.006	−.010
P-91	18⅝-inch static tube pointing downstream	2.0	−.004		−.002		−.004	−.006		−.002		−.008
		2.8	−.009	−.006	−.004	−.005	−.006	−.003	−.001	−.004	−.011	−.011
P-92	18¾-inch static tube pointing downstream	2.0	−.003		−.002		−.004	−.002		−.002		−.006
		2.8	−.007	−.005	−.004	−.003	−.005	−.003	0	−.004	−.004	−.010
P-93	19-inch static tube pointing upstream	2.8	−.007		−.003		.007	0		.003		0
P-93	19-inch static tube pointing downstream	2.8	−.006		−.005		−.007	−.007		−.005		−.009
P-94	13-inch static tube pointing upstream	2.8	−.005		.005		.004	.002		.005		−.004
P-94	13-inch static tube pointing downstream	2.8	−.009		−.005		−.010	−.008		−.005		−.012
P-95	12½-inch static tube (round nose) pointing upstream	2.8	−.007		.002		.003	0		.002		−.005
P-95	12½-inch static tube (round nose) pointing downstream	2.8	−.010		−.004		−.010	−.009		−.004		−.015
P-96	18-inch static tube pointing upstream	2.8	−.006		.007		.009	.004		.007		0
P-96	18-inch static tube pointing downstream	2.8	−.004		0		−.006	−.005		0		−.008
P-97	12-inch static tube pointing upstream	2.8	−.002		.008		.009	.002		.007		.001
P-97	12-inch static tube pointing downstream	2.8	−.003		0		−.006	−.005		0		−.009
P-98	12-inch static tube (round nose) pointing upstream	2.8	−.006		.006		.007	.004		.006		−.0[illegible]3
P-98	12-inch static tube (round nose) pointing downstream	2.8	−.003		.001		−.007	−.005		.001		−.009
L-99	12-inch static tube pointing upstream	2.8	−.006		.004		.012	0		.004		−.002
L-99	12-inch static tube pointing downstream	2.8	−.013		−.003		−.008	−.011		−.003		−.019
	BAFFLES											
P-72	Twitchell, 6 inches long, projecting 3 inches from end of pipe	2.0	−.010	−.005	−.001	.005	.013	−.005		−.001		−.006
		2.8	−.020	−.011	0	.008	.022	−.010		0		−.010
P-74	Ash, 5½ inches long, projecting 2¾ inches from end of pipe	2.0	−.007	−.005	−.001	.003	.009	−.001		−.001		−.003
		2.8	−.017	−.010	0	.008	.015	0		0		−.002

	STREAM-LINE BOXES											
P-46	Kinnison	2.0	−.012		−.007		−.009	−.011		−.007		−.008
		2.8	−.019	−.016	−.014	−.013	−.015	−.014	−.011	−.014	−.013	−.011
P-53	Eisenlohr	2.0	−.004	−.007	−.006	−.006	−.002	−.005	−.002	−.006	−.011	−.011
		2.8	−.009	−.005	−.006	−.005	−.001	−.009	−.001	−.006	−.011	−.016
	FLAT PLATES											
P-49	Circular plate, 16 inches in diameter	2.8	−.014	−.010	−.010	−.006	.003					
P-50	Rectangular plate, 12 x 24 inches	2.0	−.010	−.008	−.002	0	0	−.005		−.002		−.006
		2.8	−.019	−.015	−.006	−.003	.005	−.009		−.006		−.010
P-88	Flat plate extending to bottom of flume [2]	2.0			0							
		2.8			−.005							
	MISCELLANEOUS											
P-39	3-inch pipe cut square [3]	2.8	−.078	−.084	−.081	−.074	−.062					
		2.8	−.122	−.140	−.146	−.142	−.116	−.149		−.146		−.146
P-58	Standard 3-inch tee, flow through run	2.8			−.059							
P-62	Same as P-58 except no threads in run	2.8			−.100							
P-75	Walworth strainer pointing out	2.8			−.048							
P-76	Walworth strainer pointing downstream	2.8	−.011	−.009	−.010	−.010	−.008					
P-80	Static tube perpendicular to flow	2.8			−.222							

[1] See pp. 57–58 for statement regarding number and size of holes in each tube.
[2] Could not be used in any other position.
[3] End of pipe projecting 17½ inches from wall.

TABLE 8.—*Comparison of tests of full-size models of devices for use with various sizes of pipes at a velocity of 2.8 feet per second*

Model			Difference, in feet, in elevation of water surface in well from that in flume									
			Horizontal angle					Vertical angle				
No.	Size of pipe (inches)	Description	−10°	−5°	0	+5°	+10°	−10°	−5°	0	+5°	+10°
L-79	2	Static tube	−0.021	−0.004	0.007	0.006	0.007	0.004	0.003	0.007	0.004	0.003
M-79	2½	do	−.014	−.008	.004	.004	.007	.001	.005	.004	.002	0
P-79	3	do	−.020	−.006	.004	.006	.008	.001	.003	.004	.003	.003
L-83	2	do	−.010	−.004	−.003	−.005	−.010	−.006	−.005	−.003	−.002	−.005
M-83	2½	do	−.012	−.004	−.002	0	−.007	−.003	−.001	−.002	−.007	−.006
P-83	3	do	−.013	−.008	−.004	−.006	−.013	−.008	−.008	−.004	−.010	−.008
L-72	2	Twichell baffle 5¼ inches long, projecting 2⅝ inches	−.021	−.015	−.003	.008	.014	−.012		−.003		−.015
M-72	2½	Twichell baffle 5¾ inches long, projecting 2⅞ inches	−.018	−.010	0	.007	.018	−.009		0		−.008
P-72	3	Twichell baffle 6 inches long, projecting 3 inches	−.020	−.011	0	.008	.022	−.010		0		−.010
Q-72	4	Twichell baffle 7 inches long, projecting 3½ inches	−.014	−.011	0	.005	.016	−.010		0		−.009
L-74	2	Ash baffle 4½ inches long, projecting 2¼ inches	−.015	−.012	−.001	.010	.014	0		−.001		0
M-74	2½	Ash baffle 5 inches long, projecting 2½ inches	−.012	−.008	−.001	.008	−.002			−.001		−.002
P-74	3	Ash baffle 5½ inches long, projecting 2¾ inches	−.017	−.010	0	.008	.015	0		0		−.002
Q-74	4	Ash baffle 6¼ inches long, projecting 3⅛ inches	−.016	−.008	.001	.010	.020	−.005		.001		−.008
M-49	2½	Circular plate, 16 inches in diameter	−.016	−.014	−.007	−.004	.006					
P-49	3	do	−.014	−.010	−.010	−.006	.003					
H-35	1	Straight pipe cut square			−.168							
K-36	1½	do			−.163							
L-37	2	do			[1] −.161							
M-38	2½	do			−.152							
P-39	3	do	−.122	−.140	−.146	−.142	−.116	−.149		−.146		−.146
Q-40	4	do			[2] −.133							
L-58	2	Standard tee with outlet on pipe, flow through run			−.040							
M-58	2½	do			−.051							
P-58	3	do			−.059							
L-62	2	Standard tee with outlet on pipe, threads removed from run			−.062							
M-62	2½	do			−.078							
P-62	3	do			−.100							
L-63	2	Handrail tee, flow through run, no threads in run			−.033							

[1] −0.082 foot at 2.0 feet per second.

[2] −0.069 foot at 2.0 feet per second.

TABLE 9.—*Tests of Twitchell and Ash baffles of various lengths with different sizes of pipes*

TWITCHELL BAFFLES

A models

Model No.	Size of pipe (inches)	Length of baffle		Velocity at intake (feet per second)	Difference, in feet, in elevation of water surface in well from that in flume						
					Horizontal angle					Vertical angle	
		Total length (inches)	Projection from pipe (inches)		−10°	−5°	0°	+5°	+10°	−10°	+10°
A-67	3/8	1.42	0.75	2.8	0.004	0.012	0.012	0.018	0.019		
A-72	3/8	1.03	.00	2.8			−.152				
A-72	3/8	1.03	.12	2.8			−.094				
A-72	3/8	1.03	.25	2.8			−.032				
A-72	3/8	1.03	.38	2.8			−.019				
A-72	3/8	1.03	.56	2.8	−.020	−.013	−.002	.005	.014	−0.010	−0.004
A-72	3/8	1.03	.62	2.8	−.020	−.009	.001	.011	.018		

Full-size models

Model No.	Size of pipe (inches)	Total length (inches)	Projection from pipe (inches)	Velocity at intake (feet per second)	−10°	−5°	0°	+5°	+10°	−10°	+10°
L-72	2	5.00	2.50	2.8			−0.007				
L-72	2	5.25	2.62	2.8	−0.021	−0.015	−.003	0.008	0.014	−0.012	−0.015
M-72	2½	5.50	2.75	2.8			−.002				
M-72	2½	5.75	2.88	2.8	−.018	−.010	.000	.007	.018	−.009	−.008
P-72	3	5.00	2.50	2.8			−.008				
P-72	3	5.50	2.75	2.8			−.003				
P-72	3	6.00	3.00	2.8	−.020	−.011	.000	.008	.022	−.016	−.010
P-72	3	7.00	3.50	2.8			.004				
P-72	3	8.00	4.00	2.8			.006				
Q-72	4	7.00	3.50	2.8	−.014	−.011	.000	.005	.016	−.010	−.009
Q-72	4	7.25	3.62	2.8			.002				
Q-72	4	7.75	3.88	2.8			.004				
Q-72	4	8.00	4.00	2.8			.005				

TABLE 9.—*Tests of Twitchell and Ash baffles of various lengths with different sizes of pipes*—Continued

ASH BAFFLES

A models

Model No.	Size of pipe (inches)	Length of baffle: Total length (inches)	Length of baffle: Projection from pipe (inches)	Velocity at intake (feet per second)	Difference, in feet, in elevation of water surface in well from that in flume: Horizontal angle −10°	Horizontal angle −5°	Horizontal angle 0°	Horizontal angle +5°	Horizontal angle +10°	Vertical angle −10°	Vertical angle +10°
A-74	¼	0.60	0.30	2.8			−0.009				
A-74	¼	.69	.34	2.8			−.004				
A-74	¼	.75	.38	2.8			.000				
A-74	¼	1.00	.50	2.8			.014				
A-74	¼	.72	.36	2.8			−.011				
A-74	¼	.75	.38	2.8			−.015				
A-74	¼	.94	.47	2.8			−.004				
A-74	¼	1.00	.50	2.8			.002				
A-74	¼	1.25	.62	2.8			.011				
A-74	¼	1.38	.50	2.8			.003				
A-74	¼	1.38	.75	2.8			.008				
A-74	¼	1.44	.75	2.8	0.015	0.030	.023	0.039	0.045	0.033	0.032
A-74	¼	1.07	.38	2.8			.010				
A-74	¼	.94	.25	2.8			−.009				
A-74	¼	.56	.31	3.65	−.039	−.030	−.026	−.020	−.013		
A-74	¼	.88	.31	3.65	−.013	−.007	.007	.023	.026		
A-74	¼	1.12	.31	3.65			.010				
A-74	¼	.75	.38	3.65	−.016	−.007	.003	.013	.020		
A-74	¼			1.0	−.003	−.003	−.001	.000	.000		
A-74	¼			1.0	−.003	−.003	−.002	−.002	−.002		
A-74	¼	.88	.44	1.0	−.001	−.001	−.001	.000	.001		
A-74	¼			2.8	−.013	−.008	−.002	.000	.005	−.005	−.003
A-74	¼	1.00	.50	2.8			.003				
A-74	¼	1.50	.75	2.8			.022				
A-74	¼	.75	.38	2.8	−.024		−.012		−.002		
A-74	¼	.88	.44	2.8	−.021		−.007		.002		
A-74	¼	1.00	.50	2.8	−.015		−.004		.008		
A-74	¼	1.12	.56	2.8	−.016		−.001		.009		
A-74	¼	.88	.59	2.8	−.015		.000		.009		
A-74	¼	1.00		2.8	−.017		−.005		.006		
A-74	¼	1.12		2.8	−.014		.001		.013		
A-74	¼	1.19		2.8	−.016		.002		.016		
A-74	¼	1.25		2.8	−.015		−.001		.014		
A-74	¼		.62	2.8	−.013		.003		.018		
A-74	¼	2.00	1.00	2.8			.024				

Full-size models

L-74	2	3.5	1.75	2.8			−0.008				
L-74	2	4.5	2.25	2.8	−0.015	−0.012	−.001	0.010	0.014	0.000	0.000
L-74	2	5.5	2.75	2.8			.006				
M-74	2½	4.0	2.0	2.8			−.006				
M-74	2½	5.0	2.5	2.8	−.012	−.008	−.001	.008	.018	−.002	−.002
M-74	2½	6.0	3.0	2.8			.008				
P-74	3	5.0	2.5	2.8			−.006				
P-74	3	5.5	2.75	2.8	−.017	−.010	.000	.008	.015	0.000	−.002
P-74	3	6.0	3.0	2.8			.006				
Q-74	4	6.0	3.0	2.8			−.002				
Q-74	4	6.25	3.12	2.8	−.016	−.008	.001	.010	.020	−.005	−.008
Q-74	4	6.5	3.25	2.8			.003				
Q-74	4	7.0	3.5	2.8			.006				

COLLECTION OF DEBRIS ON INTAKE

The relation ordinarily existing between the heights of water in the river channel and in the stilling well where the records of stages are obtained may be changed if debris becomes lodged or collects at the end of the intake pipe in such a manner as to interfere with the free movement of the water into and out of the gage well. In order to obtain some information regarding the effects of debris on the performance of intake devices, the collection of debris in the 3-foot flume was simulated by means of an ordinary cement sack which was placed in the flume and allowed to drift down with the current until it came into contact with the end of the intake pipe and partly covered the intake device. The results obtained are shown in table 10 and should be considered as being qualitative rather than quantitative, as the conditions of the experiments could not be exactly duplicated for the various intake devices.

Table 10.—*Effects of collection of debris on intake*

Intake		Difference in elevation, in feet, of water surface in well from that in flume	
No.	Description	With sack	Without sack
P-74	Ash Baffle:		
	Sack covering pipe and one-half of baffle	−0.090	0
	Sack covering pipe and baffle	−.110	0
	Sack covering pipe and baffle and draped around end of baffle	−.086	0
P-89	Short static tube with ring of holes, pointing downstream	−.055	−.002
P-79	Static tube with holes top and bottom, pointing upstream	−.036	.004
P-83	Static tube with holes top and bottom, pointing downstream	−.065	−.004
P-53	Eisenlohr box:		
	All but inner 6 inches of box covered	−.073	−.006
	All but inner 12 inches of box covered	−.057	−.006
	Outer 6 inches of box covered	−.045	−.006
P-50	Flat plate 12 by 24 inches:		
	Sack caught on upstream end with ends over top and bottom of plate	−.016	−.006
	Sack hooked on upstream end with part on back and rest covering face of plate	−.040	−.006
P-76	Walworth strainer pointed downstream	−.053	−.010
P-49	Circular plate	−.044	−.010
P-46	Kinnison box	−.069	−.014

REMOVAL OF SILT BY FLUSHING

The ease and completeness with which the devices attached to intake pipes may be cleaned and accumulations of silt removed from the intakes by the flushing apparatus usually installed in gage structures is an important consideration in the selection of the design. Intakes having large openings might be expected to flush more readily than those having small openings, even though the number of the small openings was large enough to give the same total area. In order to

obtain some information with respect to the ease of flushing of various intake devices, particularly the different designs of static tubes, provision was made for experimental tests under conditions similar to those existing at gaging stations equipped with facilities for flushing intake pipes.

FLUSHING APPARATUS

A cylindrical steel tank about 6 feet in diameter was available as a source of water for the flushing tests. This tank was provided with a glass manometer and had been calibrated so that the amount of water discharged from it could be determined from the manometer readings. The average head used in flushing was about 21 feet, the reduction in head during a test because of the drop of the water level in the tank being only about 0.2 foot. The area of the cross section of the tank was such that a difference of 0.2 foot in the height of water corresponded to a release of 43.6 gallons.

A 4-inch pipe line, which was reduced from an 8-inch pipe line 12 feet above the outlet, was connected to a quick-acting valve. A 4-inch to 3-inch reducing bushing on the outlet of the valve was connected to a 6-foot length of 3-inch pipe to which the various static tubes and other intake devices were attached by means of a 90° elbow. In making the flushing tests, the intake devices were filled with soft mud or silt and then attached to the elbow of the 3-inch pipe. By observing the time between the opening and closing of the quick-acting valve and the corresponding drop of the water in the tank, the discharge through the intake device, in gallons per second, was determined. Observations of the amounts of water discharged through the devices in equal intervals of time without the use of silt were also made for purposes of comparison.

TESTS

The static tubes and other devices were flushed with clean water and then filled with mud and flushed again. The mud was a soft clay that would just start to flow out of the holes in the static tubes under a head of about 1 foot. Each tube was completely filled with mud back to the elbow connection. In flushing out the mud, the quick-acting valve was opened for 15 seconds and then closed, the amount of water discharged during that period being considered a measure of the efficiency of the device under the flushing test. No mud remained in the tubes after flushing, except for a few small pieces between the last holes and the plugged end of the tube in some of the longer models. The 3-inch pipe, corresponding to model No. P–39, was flushed with clear water as a basis of comparison. The results of the tests are shown in the following table:

TABLE 11.—*Flushing tests of intake devices for 3-inch pipe*

Model No.	Number and size of holes	Total area of openings (square inches)	Tube clean		Tube filled with mud; valve open for 15 seconds, then closed	
			Time (seconds) for discharge of 43.6 gallons of water under 21 feet average head	Discharge (gallons per second)	Discharge during 15 seconds (gallons)	Discharge (gallons per second)
P-39	End cut square	7.4	4.6	9.5		
P-79, P-83	8 holes ¾ inch in diameter top and bottom	7.1	7.5	5.8	85.0	5.7
P-89	4 rings of 4 holes, ¾ inch in diameter	7.1	7.9	5.5	80.7	5.4
P-90	5 rings of 2 holes, ¾ inch in diameter	4.4	9.8	4.4	62.6	4.2
P-96	6 rings of 6 holes, 9/16 inch in diameter	8.9	6.6	6.6	91.6	6.1
P-92	5 rings of 6 holes, 9/16 inch in diameter	7.5	7.4	5.9	85.0	5.7
P-53	Eisenlohr box	7.5			80.7	5.4
P-93	5 rings of 4 holes, ¾ inch in diameter	8.8	6.7	6.6		
P-94	do	8.8	7.0	6.3		
P-95	do	8.8	7.0	6.3		

For the condition of "tube filled with mud" the intake device was completely filled with a soft clay mud. Mud would just start to flow out of holes under about a 1-foot head. At the end of the 15-second run the mud was all removed except for a few lumps between the holes and the closed end in models P-77, P-78, and P-79.

RESULTS OF THE INVESTIGATION

The results of the tests of the full-size models that were selected for study in the large flume after the elimination of a large number of designs by tests of small models in the 10-inch flume indicated that the static tubes were the most effective devices for eliminating draw-down, consideration being given to the results obtained when the models were tested in the most favorable position with respect to direction of flow past the intake and also to the results obtained when there was angularity of flow. The performance of the Ash baffles and the Twitchell baffles was practically as good as that of the static tubes if the direction of flow was at right angles to the intake, but the baffles were not as effective as the static tubes if the direction of flow was at an angle greater or less than 90°. The Eisenlohr box did not differ greatly from the static tubes in its effectiveness if there was angularity of flow and was nearly as good for all conditions. The Eisenlohr box (see pl. 31, *A*) is further considered on page 75. The Walworth strainer pointing downstream was not as satisfactory as the above-mentioned devices when the flow was at right angles to the intake but was not materially affected by angularity of flow, its effectiveness with respect to elimination of draw-down remaining about the same for a considerable amount of angularity in the direction of flow at the intake. The rectangular plate, the circular plate, and the Kinnison box (see pl. 31, *B*) came next in the order of satisfactory performance. The square plate extending to the bottom of the flume was used to simulate a model of a concrete pier. Because of its size

A. OUTLET OF 3-FOOT FLUME.

B. PIEZOMETER GAGES AND STILLING WELL FOR THE 3-FOOT FLUME.

A. EISENLOHR INTAKE BOX.

B. KINNISON INTAKE BOX.

it could be tested only in the one position, but the results were very satisfactory in that position with the flow parallel to the plate.

RECOMMENDATIONS FOR DESIGNS

Simple designs that are readily obtainable without the necessity of special castings or complicated machine work are generally desirable unless the performance of special designs appears to be more satisfactory. In the selection of the type of intake device to be used at a gaging station the effectiveness of the device should receive primary consideration. The ease and completeness with which it may be cleaned by the flushing arrangement ordinarily used in flushing the intake pipe and the manner in which it may be affected by floating debris are important factors in the operation of the station. In rivers where the water is deep and swift the installation or removal of an intake device may be expensive, and under these conditions the initial cost of the device may not be the controlling factor in its selection.

STATIC TUBES

The static tube appears to be the most satisfactory device for eliminating draw-down at intakes to gage wells, so far as could be determined from the laboratory tests.

The static-tube device may be made in various designs and in any size corresponding to the size of the intake pipe with which it is to be used. Designs of static tubes showing dimensions and arrangements of openings are illustrated in figure 5. The total area of the holes should be about 20 to 25 percent greater than the cross-section area of the pipe, in order that deposits of mud and silt may be effectively removed by flushing of the intake. The laboratory tests indicated that a suitable arrangement of openings to provide the required area for the 2-inch, 2½-inch, and 3-inch pipes may be obtained by using five rings of holes with four holes in each ring, the rings 1 inch apart and the holes staggered in alternate rings. For the 4-inch pipe, six rings with six holes each are suggested.

For pipe diameters of 3 inches or less the net length of tube between shoulders of couplings should be not less than 12 inches, and the outer rings of holes should be not less than 4 inches from the shoulders of the couplings. These dimensions correspond to those of static tubes tested in the laboratory. For pipes larger than 3 inches in diameter it is probable that the minimum length of the tube should be about four times the diameter of the pipe. The outer end of the tube may be threaded for a standard pipe coupling and closed by means of a standard plug, or it may be closed by a plug specially fitted to the inside of the pipe. If preferred, a cap may be used instead of the coupling and plug. The use of a special round-nose plug did not give

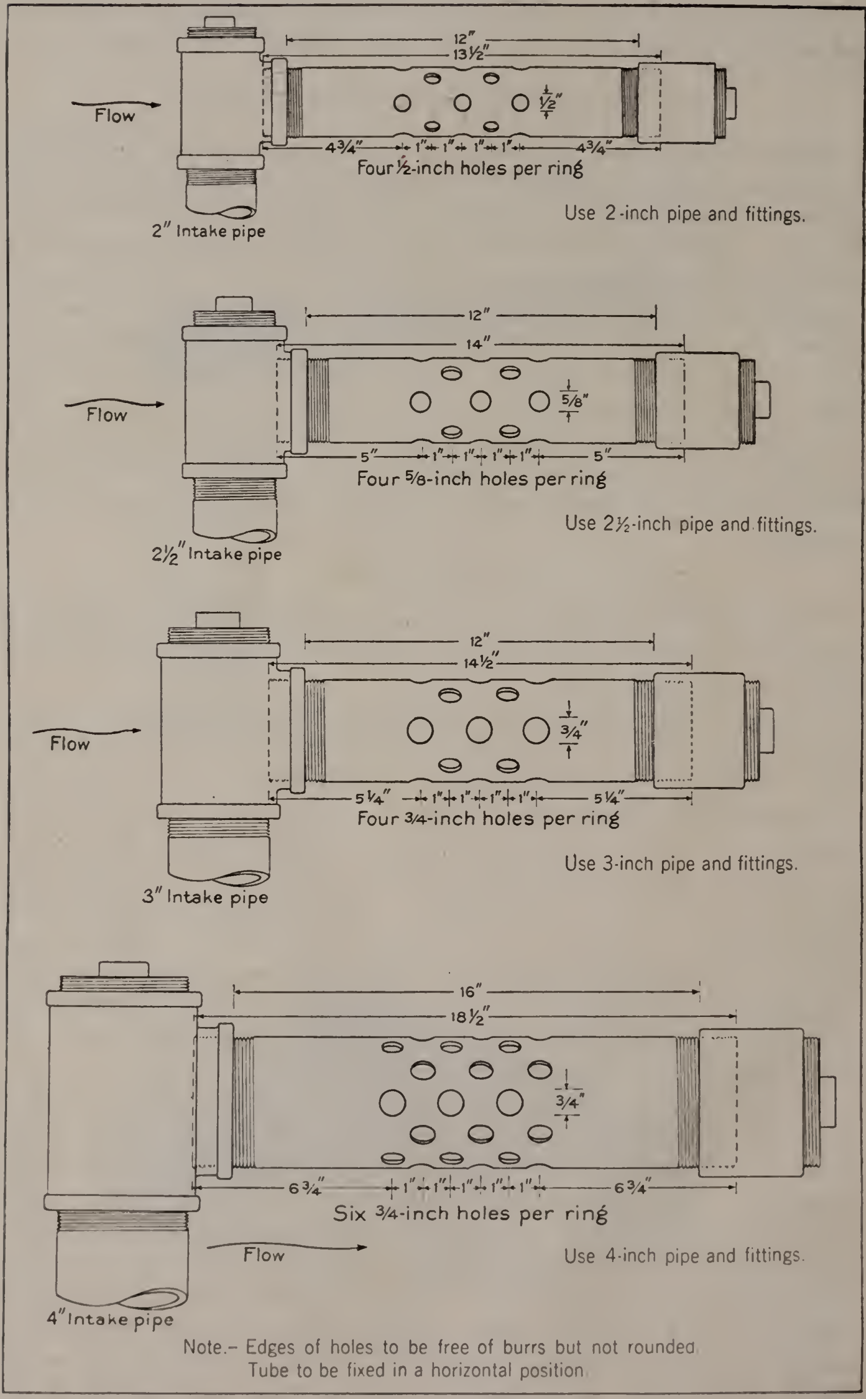


FIGURE 5.—Designs of static tubes for use with 2-inch, 2½-inch, 3-inch, and 4-inch intake pipes.

results materially different from those obtained with the standard coupling and plug. The hydraulic performance of static tubes made in the lengths specified above was the same when the tubes were pointing upstream or downstream, but less difficulty because of submerged drift and debris may be expected if the tube is used pointing downstream.

The static tube may be connected to the intake pipe by means of a 90° elbow or by a standard tee. If the intake pipe points upstream from an artificial control, the connection may be made as shown in figure 6. The tube should be fixed securely in a horizontal position, and provision made so that it will not tilt downward by turning of the coupling under its own weight or any additional weight that may be placed upon it. In using a standard tee connection the static tube should be attached to the leg of the tee, the run of the tee opposite the well being closed with a plug.

The static tube devices tested at the National Hydraulic Laboratory were constructed of so-called "wrought iron" pipe with threaded ends for connection to standard pipe fittings. One end of the tube was connected to a standard pipe elbow. At the other end there was a sleeve coupling into which a standard plug was screwed for closing the end of the tube. The "length" of the tube was considered to be the distance along the tube between the protuberances of the coupling and the elbow; the gross length of the tube, including the threaded ends, consists of the so-called "tube length" plus the distances to which the coupling and the elbow are screwed on the pipe. It was the intention to test such designs as could readily be constructed by pipe fitters, using materials that could be obtained at stores and shops dealing in ordinary pipe fittings. The holes were drilled straight through the tubes, any roughness or "burr" being smoothed off, but with no bevel or rounding of the edges. The tubes were made long enough to extend beyond the disturbance caused by the elbow and the intake to the well.

The static tubes may be made of ordinary wrought-iron pipe and pipe fittings, or of galvanized wrought-iron pipe. Other materials, such as brass, bronze, copper, or stainless steel, may be used if desired. The first cost of tubes made of ordinary wrought-iron pipe, either plain or galvanized, is comparatively small, whereas the first cost of tubes made of other materials would be somewhat larger, and their performance probably would be no better than that of the less expensive tubes if the latter were not affected by corrosion. However, if the effectiveness of the tubes made of so-called "wrought iron" pipe became impaired by accumulations due to corrosion, the cost of their replacement in deep, swift water might be much greater than the first cost of tubes made of noncorrosive material.

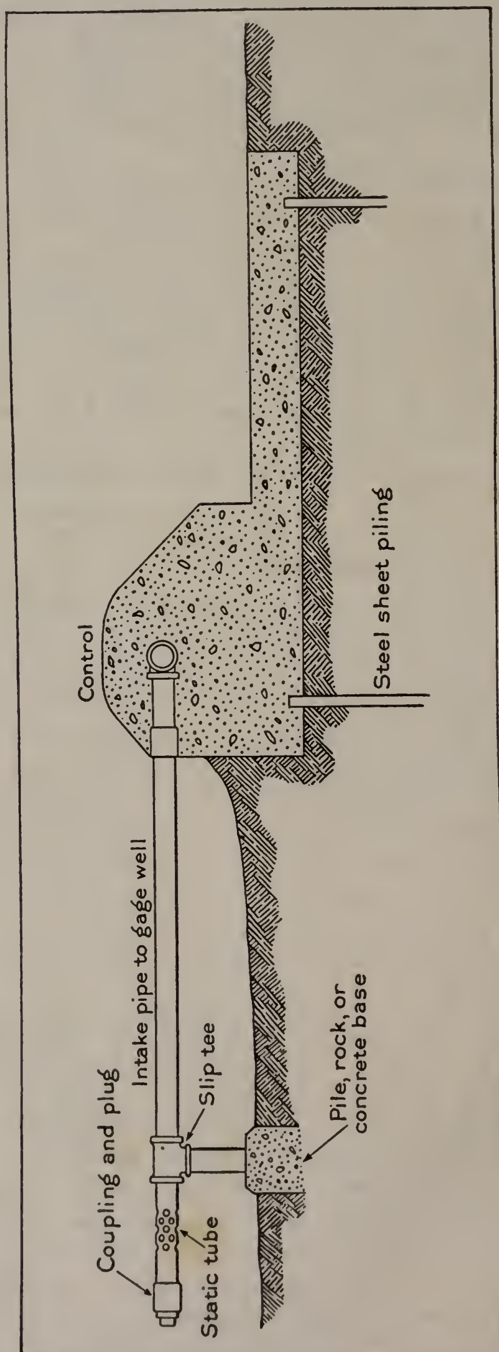
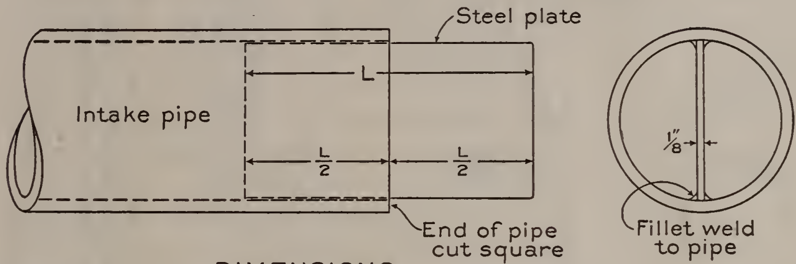


FIGURE 6.—Static-tube connection to intake pipe of gage well at stream-flow measurement station provided with artificial control.

BAFFLES

The Ash baffle and the Twitchell baffle appear to give practically as good results as the static tube where the direction of flow is at an angle of 90° to the intake, but are not as effective if the direction of flow is at an angle considerably greater or less than 90°.



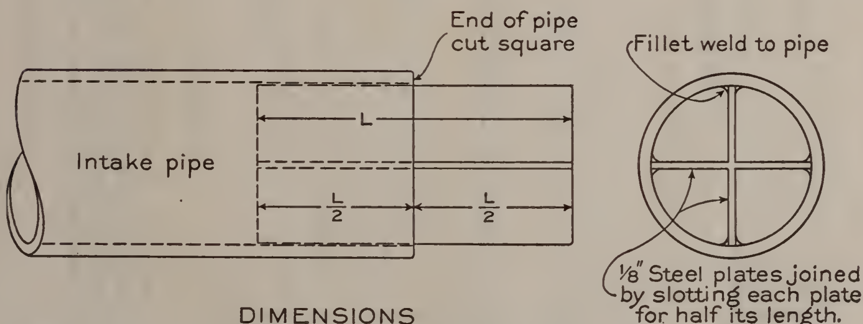
DIMENSIONS

Baffle to be of such width that it will fit snugly inside pipe. Length to be as shown in table.

Nominal diameter of pipe	Length of baffle L
2"	4½"
2½"	5"
3"	5½"
4"	6¼"

Baffle to be fixed in vertical position normal to current.

FIGURE 7.—Design of Ash baffles for intake pipes of various sizes.



DIMENSIONS

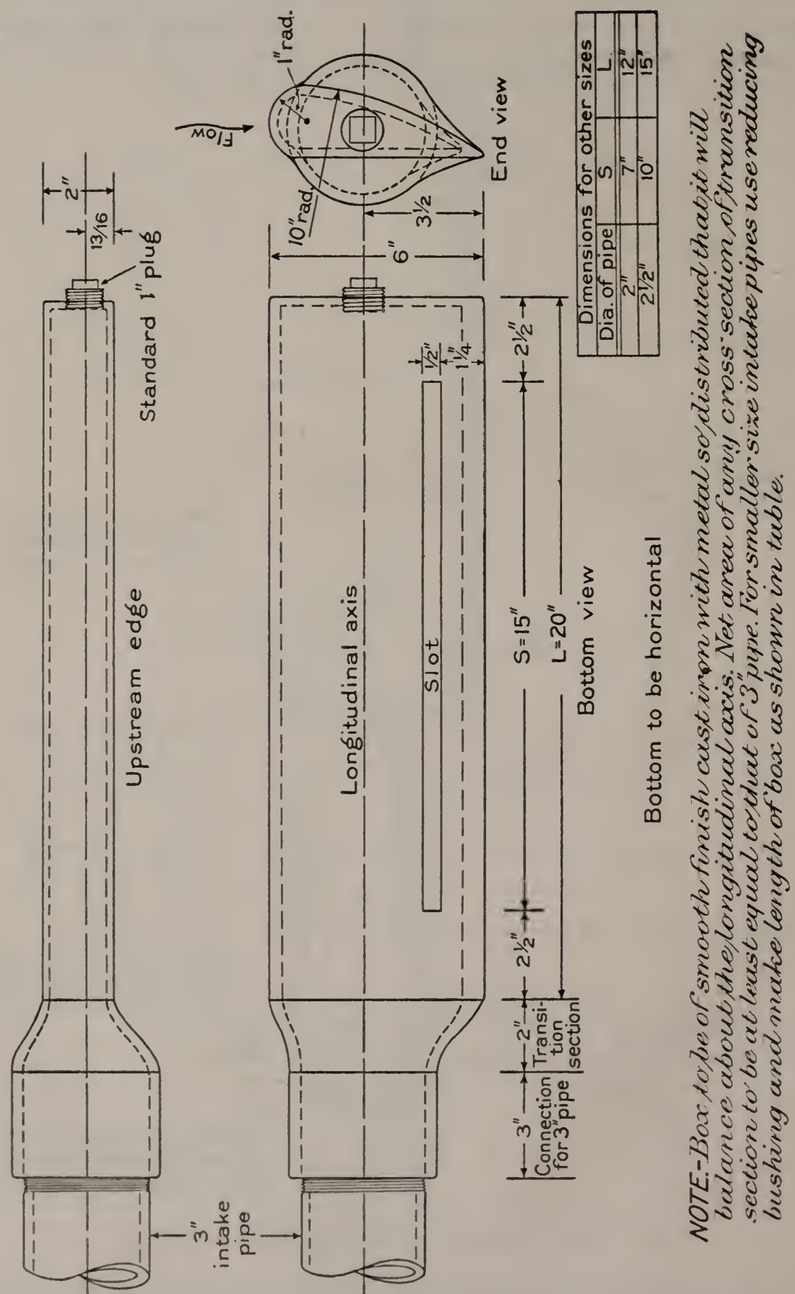
Baffle plates to be of such width that they will fit snugly inside pipe. Length to be as shown in table.

Nominal diameter of pipe	Length of baffle L
2"	5½"
2½"	5¾"
3"	6"
4"	7"

Baffle to be fixed in position with plates horizontal and vertical.

FIGURE 8.—Design of Twitchell baffles for intake pipes of various sizes.

All the baffles were made of ⅛-inch metal and projected out of the pipe a distance equal to half their length. The proper length of these baffles as determined by tests for the various sizes of intake pipes (see table 9) are shown in figures 7 and 8.



Dimensions for other sizes		
Dia. of pipe	S	L
2"	7"	12"
2½"	10"	15"

FIGURE 9.—Design of Eisenlohr intake box.

OTHER DEVICES

Several of the other devices gave satisfoctory results and deserve mention because of certain desirable features in the individual designs. In the Eisenlohr intake box (see pl. 31, *A*, and fig. 9) the center of gravity of the device is in line with the axis of the intake pipe, and therefore there is no tendency for the device to turn from the position in which it is intended to be used. This device might be expected to receive considerable use except for the fact that it must be made from a special casting and requires machine-shop work in finishing. The Walworth strainer pointing downstream gave good results in the laboratory tests and, of course, can be readily purchased as a commercial product. The tests of the A models of flat plates that were intended to simulate the effects of a concrete pier flush with the end of the intake pipe and the tests of the circular plate attached to the end of the pipe indicated that the use of a vertical pier or plate at a clockwise angle of 5° with the direction of flow was effective in materially reducing the amount of draw-down. The merits of various other devices can be judged by reference to the tables showing their performance.

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